Master's Thesis

HIS Development with the Participation of Medical Practitioners in Design Applying Agile Principles: A Case Study for Occupational Health Management Service

Do Kyung Kim

Department of Biomedical Engineering

(Human Factors Engineering)

Ulsan National Institute of Science and Technology

2021

HIS Development with the Participation of Medical Practitioners in Design Applying Agile Principles: A Case Study for Occupational Health Management Service

Do Kyung Kim

Department of Biomedical Engineering

(Human Factors Engineering)

Ulsan National Institute of Science and Technology

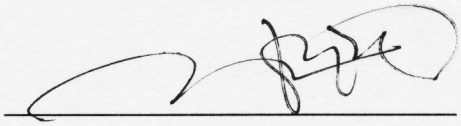
HIS Development with the Participation of Medical Practitioners in Design Applying Agile Principles: A Case Study for Occupational Health Management Service

A thesis submitted to
Ulsan National Institute of Science and Technology
in partial fulfillment of the
requirements for the degree of
Master of Science

Do Kyung Kim

07.09.2021 of submission

Approved by



Advisor
Doo Young Jung

HIS Development with the Participation of Medical Practitioners in Design Applying Agile Principles: A Case Study for Occupational Health Management Service

Do Kyung Kim

This certifies that the thesis of Do Kyung Kim is approved.

07.09.2021 of submission

Signature

Advisor: Doo Young Jung

Signature

Hwang Kim

Signature

Chiehyeon Lim

Abstract

This case study illustrates the early development process of an OHS manager-centered health information system (HIS) with multiple agents and end user groups, including company managers and employees. This study aims to suggest an approach to encompass the non-designer into the design process, especially medical practitioners, as a critical role for a highly changeable and complex healthcare project.

Occupational Health and Safety (OHS) management is the practice of an organization to provide work and working conditions free from the recognized hazards for their employees. The health institute entrusted for OHS management dispatches the medical and occupational professionals to the workplaces. The management through health counseling, monitoring, and advice to the companies and the employees.

Therefore, this study discussed the design process to improve the work of entrusted OHS practitioners, which focused on employee health consultation at the most. As a result, an iterative framework adopting Agile principles is suggested to encourage frontline medical staff and stakeholders to collaborate in decision-making and ideas.

As the result, the occupational health management information system is designed its user experience (UX) and interfaces (UI) based on the findings obtained from the iterative and incremental design process. The frontline OHS practitioners of Wonju Severance Christian Hospital, and Seoul National University Hospital (SNUH) Psychiatry participated to the interview and activities in the workshops.

Although this is a case study conducted on the OHS management of a commissioned hospital, the approach and strategies would be available to apply on the other HIS project or healthcare.

Contents

List of Figure

List of Table

I. Introduction

1.1. Background

Bringing healthcare professional from different fields together at a same table is a significant move ever since HIS (Health Information System) was developed [1]. More effort and attention were paid to the design and development of applications, and the fields increased their diversity [2]. It had been discussed that healthcare from now on requires digital data-oriented computational information systems. However, the process of developing it is remained controversial.

Questions have arisen while the new IT-based communication tools are delivered to the practitioners; are those satisfying, and are those solutions implement the feedback and needs from the frontlines users [3, 4]. According to a study conducted in Finland [5], a survey result showed more than 2600 doctors interested in participating in collaborative activities with the HIS development team. In summary, the survey figured out the needs and willingness of the healthcare practitioners to share their experience and feedback with software providers for better outcomes.

Often the process for requirements gathering and research on the experience of healthcare providers are accounted as time-consuming in developing a large-scale medical information system. However, to mute the voice of the end-user might have ended up setting the wrong goal. What makes the worse here, if the development process is linear, adjustments at the later stage of development increase additional expenditure [6]. The linear development process called the waterfall model is named because it is hard to be rewound. This approach assumes the whole system development progress is predictable and is carried out as planned in the first place. Every requirement must be recognized from the beginning.

It is clear why medical staff needs to participate in the design and decision-making process of the HIS development; because it is challenging to build understanding as much prompt as planning requires between teams in different fields. Decision-making carried by a solitary developing department would have limited reflecting the extraordinary use environments like medical staff's experience.

Furthermore, platforms that function as bridges between different user groups may require as many touchpoints as the number of groups. As the needs of each group and the resulting touchpoints increase, the service area would require to widens its coverage. The scope of the HIS platform designed throughout this study is vast to cover the overall work of medical staff and personnel in charge of the company and the results of workers' examinations and health counseling.

Indeed, it is not simple to ensure that the medical staff and the design team can fully understand each other in an insufficient time. Moreover, the majority of health and medical division were unfamiliar with the design process. Therefore, only the frontline healthcare providers participate in design

decision-making, the project is possible to aim for the solutions that support the distinctive nature of context: the performance of healthcare services.

1.2. Scope and challenges of the case study

Pre-conducted researches had been discussed on whether existing occupational health care management was an adequate intervention, or the outcomes [7, 8]. However, there is a lack of discussion or research on how the occupational health management service is delivered. In addition to this, limitations were found that the administration of OHS reporting relied on analog media, such as handwritten hardcopy documents for the record of processes and outcomes of services provided. The more information is recorded on the hard copy, the more difficult it is to manage. The medical team's cognitive capabilities are currently spent browsing data among a bundle of documents, just as the expression "Drowning in Data [9]" since the absence of the proper information system.

Therefore, this study aims to design an online HIS platform to support OHS management services. The occupational management platform would function as an online workspace to store health data from employees and firms, which is now scattered in analog format. If management logs and health information are accessible to re-reference and accumulated into analysis-friendly forms of data, those can be used to establish future healthcare plans based on follow-up observations and statistics

This study will discuss the early stage of HIS development for improving the entrusted health management, specifically focusing on employee's health counseling and monitoring health information. Also, this study would describe the research framework and strategies contrived to encourage frontline medical staff and research institutes to collaborate in decision-making and ideas.

II. Literature Review

2.1. Health Information System

Isern [2] argued "There is a wide variety of sources of information (data from electronic medical records, data from medical devices, notes taken daily) that should be taken into account to deliver care to the patient, and artificial agents may cooperate with humans to facilitate the development and enactment of a care plan " on the health information system (HIS) and the agents of it. Lippeveld et al [10] defined HIS as a system provide health related information to support the decision-making process at each level of organization, including information on diseases and on the output of the health service.

The chapters of HIS had been pointed out in [11]; the fundamental development is "the shift from paper-based to computer-based processing and storage". Based on the digital data foundation, the expending of HIS was described as the direction to aims; such as inclusion with patients, professionals, and inter-organizational application.

Criteria	Purpose	Target user
Classification	Data-management systems.	Patient-centred applications
	Decision support systems (DSSs)	Staff-centred applications
	Planning	Healthcare organizations-centred

Table 1. The classification of the health information system[1]

Classification of HIS has been introduced in various research [2, 12, 13]. An exemplary criterion considering health service delivery is illustrated in Table 1; the purpose and the target user of the system. The purpose and target user depend on the health service and its context that the HIS sake for. For example, most of the DSSs assist clinical decision-making in the medical environment [13]. On implementing HIS, one of the failure factors criticized of a HIS is the design-reality gaps [14]. In other words, narrowing the gaps that occurred between the HIS and the target context could be the key to developing an effective system.

[1] Table 1 is a summary of the findings from D. Isern and A. Moreno, "A systematic literature review of agents applied in healthcare," *Journal of medical systems,* vol. 40, no. 2, pp. 1-14, 2016.

2.2. Agile Approach

The Agile approach was adopted to enable the entire research associates to intervene in the design process, including the medical professionals. The agile principles explain both the organizational management structure and the method of the development project [15, 16]. According to Martin C Robert [17], agile software development aims to collaborate with flexibility on projects to reach the goal. He explained that User Story and XP (Extreme Programming) are well-known Agile practices using simple techniques for continuously improving the design.

Agile development has been welcomed by many industries and companies and became a notion for an environmental setting that centers the iterative progress and cross-functional teams [18-20]. The practice of cross-functional collaboration means the non-designers need to participate in the design process, and the designer is responsible for the facilitation [21, 22].

This study adopted the Agile approach in the early stage of the UX design process. All research participants should be based on a shared understanding because the platform required by the project is vast and complex, and, above all, the medical staff's UX should be faithfully reflected. By utilizing a short cycle of repetitive improvement and feedback loops, it is expected that the demands or opinions of field practitioners can be applied timely to the design process. In addition, sharing the draft prototype could advance the conversation to fit the platform to the context.

2.3. Occupational Health and Safety Management

In many countries, occupational health and safety acts are specified in the legal regulations, which mandate employers to provide work and working conditions free from the recognized hazards. Occupational Safety and Health Administration (OSHA) of United States explains that "under the OSH Act, employers have the responsibility to provide a safe workplace[23]." Korea Occupational Safety and Health Agency (KOSHA) was founded in 1987 to enforce the law, Occupational Safety and Health Act of Korea (산업안전보건법, hereinafter the OSHA Act Korea), and the settlement of systems.

Beyond a national regulation like The Occupational Safety and Health Act of 1970 (OSH Act) of the United States, multinational corporations develop and operate global standards. Multinational corporations, including The International Labor Organization (ILO), the United Nations (UNN), the Organization for Economic Cooperation and Development (OECD), and other global institutions, have studied and reported standards and guidelines [24]. ISO 45001 Occupational Health and Safety Management is one of the representative examples of international regulation [25].

Therefore, the business owner shall hire a safety officer and a health officer, a person in charge of safety and health management, respectively. This role is described in the Korea OSH Act as a health officer. The small to the mid-sized businesses may entrust the duties of a health officer to an institution specializing in performing health management business [26]. Korean Industrial Health Association (KIHA) explains that the entrusted occupational health management is a service in which certified institutions provide technology and guidance on workplaces [27].

Out of the management area, the HIS in this study covers health counseling and health information management. Other sections are not included in this study, such as occupational safety management, environmental assessment, workplace group education.

Who Involves in Occupational Health and Safety Management

This study focuses on health counseling conducted by an entrusted healthcare team consisting of occupational-environmental medicine specialists, industrial nurses, and industrial hygienists. Topics such as inspecting protective equipment and worker training had not been addressed beyond the mention of health counseling or their report documents. Since this study deals only with the healthcare department of OHS, the OHS practitioner refers only to doctors, nurses, and industrial hygienists.

Goetsch [28] explained that the OHS management team could consist of safety engineers, industrial hygienists, occupational-environmental doctors, and industrial health nurses in general. The team manager is described as a leading role of the OHS team in his work. Here, the team manager indicates the position in which the entity is expected to perform leading duties. Therefore, they explained that no specific license is necessary to become an OHS team leader but the equivalent qualifications to demonstrate expertise in health, safety, and the industrial environment. Therefore, this managerial staff means the highest position in charge of the OHS in the organization.

According to the OSHA Act Korea, health managers refer to those appointed from among those qualified by law and specify that companies should also secure personnel necessary for health management. However, health managers revealed in literature studies were not described to have eligibility. In the study of Jo [29], no standard for medical advice had been discussed with the roles of safety managers and health managers. Their job is described as an assistant in improving the unstable state of the workplace and promoting workers' safety and health awareness [29]. In addition, his research found that 203 workplaces procured certified managers among 545; more than half of workplaces employed persons without certification as the OHS manager.

Type of users	Description
OHS Manager	The medical and healthcare providing individuals who specialized in occupational health and are certified. In this study, they are doctor, nurse, and industrial hygienist who provide health consultation to employees and reports the corporation the management result.
The Managerial Staff	The position or personnel that takes charge of administrative tasks and the implementation designated from health management in a corporation. An employee or the group of the staff assigned to monitor the health status and its maintenance or the organization.
Employees	The Individuals receiving the OHS Management service

Table 2. The user groups involved in the OHS management service

Throughout the literature review, the term which indicates the position or the person in charge of OHS management are varies depending on the context. Therefore, notations on OHS practice had been held at the level of distinction of terms based on the literature review and the observations made in this study, as summarized as shown in Table 1. OHS practitioner provides health consultations to individual employees and reports the result from it to the corporation. Doctors, nurses, and industrial hygienists are also mentioned as the medical staff. As an employed position of an organization, the managerial staff is in charge of the health status of workers. The managerial staff has to prepare appropriate responses and take measures according to the supervision or suggestion of the health manager. Depends on the organization, the position of managerial staff varies as concurrent positions with safety management affairs or other positions in the enterprise. Employees, also mentioned as individuals, are those who be delivered healthcare management.

Type of Occupational Health and Safety Management

The comparison studied in Jo [29] did not separate health and safety areas; however, the workplaces have been divided the employment patterns of OHS managers into three; *Exclusive, Concurrent*, and *Entrusting* workplaces. The study of Roy [30] mentioned two types of occupational health nurses; the in-house nurses and the dispatched nurses from outsourced health institutes. Goetsch [28] argued that the certified OHS practitioners in planning and other prevention-related duties could be more difficult when they are not in-house and readily available.

Classification of management		Description
The managerial staff	Exclusive	A staff hired only for the OHS related job
	Concurrent	A staff hired not only for the OHS tasks but also for the other affairs in a company.
The OSH practitioner	In-House (Internal)	A practitioner hired in a company directly. Therefore, the practitioner is one of the managerial staff.
	Entrusted (External)	A practitioner hired in a certified health institute or hospital where consigned with companies. The practitioners care for several companies and are dispatched for the visiting consultation.

Table 3. The classification of management

The study mainly focuses on the consignment OHS team of Wonju Severance Christian Hospital, a tertiary hospital contract with multiple workplaces. Interviews included the case of in-house health managers nonetheless.

Process of Occupational Health and Safety Management

Occupational Health management employing outsourcing health institutes follows the typical process as below:

1. Contract. An enterprise may appoint a health care organization according to the size of its workers. If the company without a directly hired doctor or nurse, then a qualified institute contrate with the business after adjusting the management coverage.

2. Proceeding according to entrustment contract. In case of an entrusted health management, the health management institution shall dispatch adequate human resources to perform management tasks. According to the statutory designation requirements, health management institutions are qualified organizations as hospitals or other prescribed organizations by the law.

3. Investigate the subject of management. OHS practitioners investigate the subjects of management, including the characteristics of the workplace. The investigation includes the working environment of workers, the details of significant work, the results of medical examinations. The managerial staff processes administrative tasks, such as preparing data or coordinating visits.

4. Management implementation. The health management team visits the workplace on a set schedule and performs the designated tasks, such as 1:1 health counseling. Health counseling is offered to the individual employees under suspicious checkup results.

5. Documentation and reporting. The OHS practitioners shall brief the managerial staff on the details newly identified as the outcomes of health management and medical intervention or statistical data from the employees. In some cases, the staff requests their needs to the OSH team extra documentation outside of the statutory obligations. The organization has to prepare and execute the reactive plan upon the problem if identified. The managerial staff takes the necessary follow-up assessment or reports additionally to the higher decision-maker or related ministries.

Among those, step 3, step 4, and step 5 are repeated periodically.

III. Method

The planning and design of the online platform for the OHS management were carried out in an iterative improvement manner through repeated feedback, applying the principles of agile development. This study includes methods to quote the direct opinions from project participants and the frontline medical practitioners for each design milestone. Therefore the methods inherit the principles from agile development, emphasizing the importance of the whole team [17].

This study scopes from identification the platform's intervention points, initial UXUI design, and its improvement. The means are field observations, interviews, and workshops for collective discussions applied at each design stage.

3.1. Research Framework: Iteration and Review

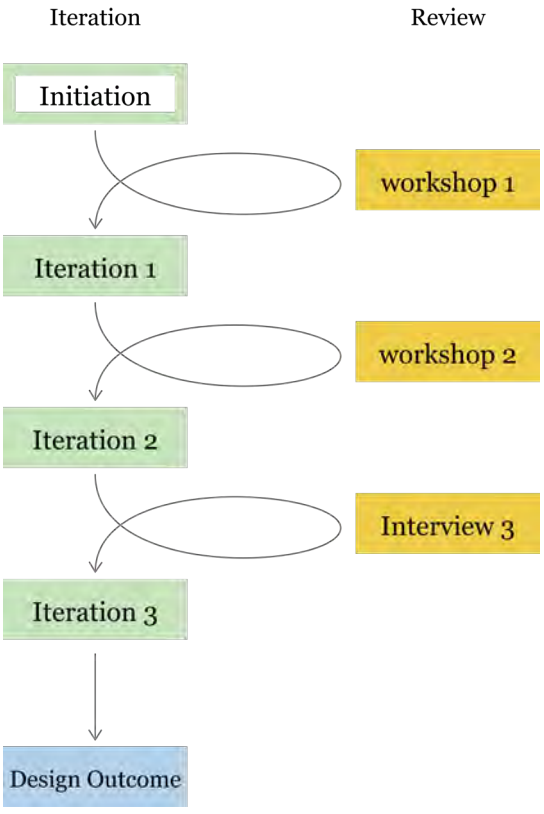


Figure 1. Research Framework

Iteration is a process skeleton that stands out in agile development. Iterative improvement widely employed agile development methods such as Sprint and Scrum [18, 31, 32]. eXtreme Programming

(XP) explains Iteration as the practice of developing on the given objectives to achieve [33]. Sprint holds a reflecting session at the closing of each Iteration called Retrospective and Review. Sprint Retrospective is a meeting about how well the Sprint went. Schwaber [31] explained, "Sprint Review is a meeting where the Team presents what was developed during the Sprint to the Product Owner and any other stakeholders that wish to attend."

Iteration in this study implies a bundle of design practices, including user research, planning, wireframing, prototyping, and studies regarding the design task. This study also employs the reflective session, adopting from Sprint. ***Review*** means the gathering of stakeholders to share what has been done in the Iteration of this study. Reviews also aim to add the perspectives from the critical clients such as the OHS practitioners and the managerial staff. Similar to the Sprint retrospective, the Iterations spares ***Retrospective and Limitation*** within the design team evaluate the agility at the end of Iteration to prepare the next cycle.

3.2. User Story

User Story is a communication tool utilizing user-centered scenario-like descriptions [34], originally invented from the XP [33]. User stories can raise the agility to share the system's accurate blueprint and carry out its succeeding tasks such as requirements gathering and release schedule [35]. Due to its benefit, the user story is one of the widely employed methods not only in the agile project but also the other engineering studies.

User story templates simple sentence as a mold; As a [type of user], I want to [do something] so that I can [get some benefit]. This sentence can be expressed in other words; As a [Who], I want [the What] so that [the Why]. The essential of the user story template is containing the designating perspective, the system requirements, and the reason [36]. The user story template had been evolved over time and still can be modified to fit the project characteristics.

Each story has to be written in the natural language of the supposed end-user. User story formulates the notation for illustrating system requirements through the lens of the user experience. This attribute drives the communication participants to consider the user at the center of the conversation. Even those who are not familiar with user-centered design thinking can prioritize in the user's shoes.

Patton [35] emphasized the importance of conversation during user story mapping, where the shared understanding is rooted. The mapping of user stories means mapping the whole system to develop described in the term of the UX flow. The conversation has to dredge throughout the service flow from how it starts and ends. Eventually, this activity increases the resolution of UX design.

IV. Progress and Results

4.1. Initiation: The First Encounter

Exploratory UX research was conducted focusing on the OHS manager's workflow. Two different management types of OHS management had been recruited for the interview. Firstly, the commissioned OHS team from a tertiary hospital (Wonju Severance Christian Hospital) had invited the design team to the moment when they are counseling. Designers had observed a pair of a doctor and a nurse delivering two cases of consultation. The unstructured interview had followed the observation. Secondly, an in-house nurse was interviewed in a semi-structured manner. She is concurrent on occupational health counseling duties who initially employed for a university (Ulsan National Institute of Science and Technology) as a school nurse.

Interviewee	Description
The entrusted OHS Team	A pair of doctor and nurse On-site observation and unstructured interview (2020. Oct. 22nd.)
In-house nurse	A nurse concurrent for school nurse tasks Semi-structured interview (2020. Nov. 11th.)

Table 4. The OHS practitioners participated for initiative user research

Result and Outcomes

With those interviews and the observation, we could identify the key end-users, their relationship, and the process of delivering the OHS counseling. Based on the interviews, diagrams were drawn to illustrate what is understood by designers to quickly sketch an outline of the system structure, project scopes, direction, service units, technical elements, and user needs.

Purpose of the Platform Intervention: Improving health care quality by increasing the efficiency of OHS tasks, applying health data collection methods in digital formats for data analytical approaches, and encouraging employee's participatory health management.

Task flow is highlighting the sequence of dispatched OHS counseling according to the interview (Figure 2). According to the interviews, the role and activities of managerial staff and employees are described. This diagram navigated designers to spot where the HIS has to engage. Therefore, by expanding the task flow, the involvement points and the number of agents of the information system have been suggested explicitly; Web dashboard for OHS practitioners, Web dashboard for companies, and Mobile

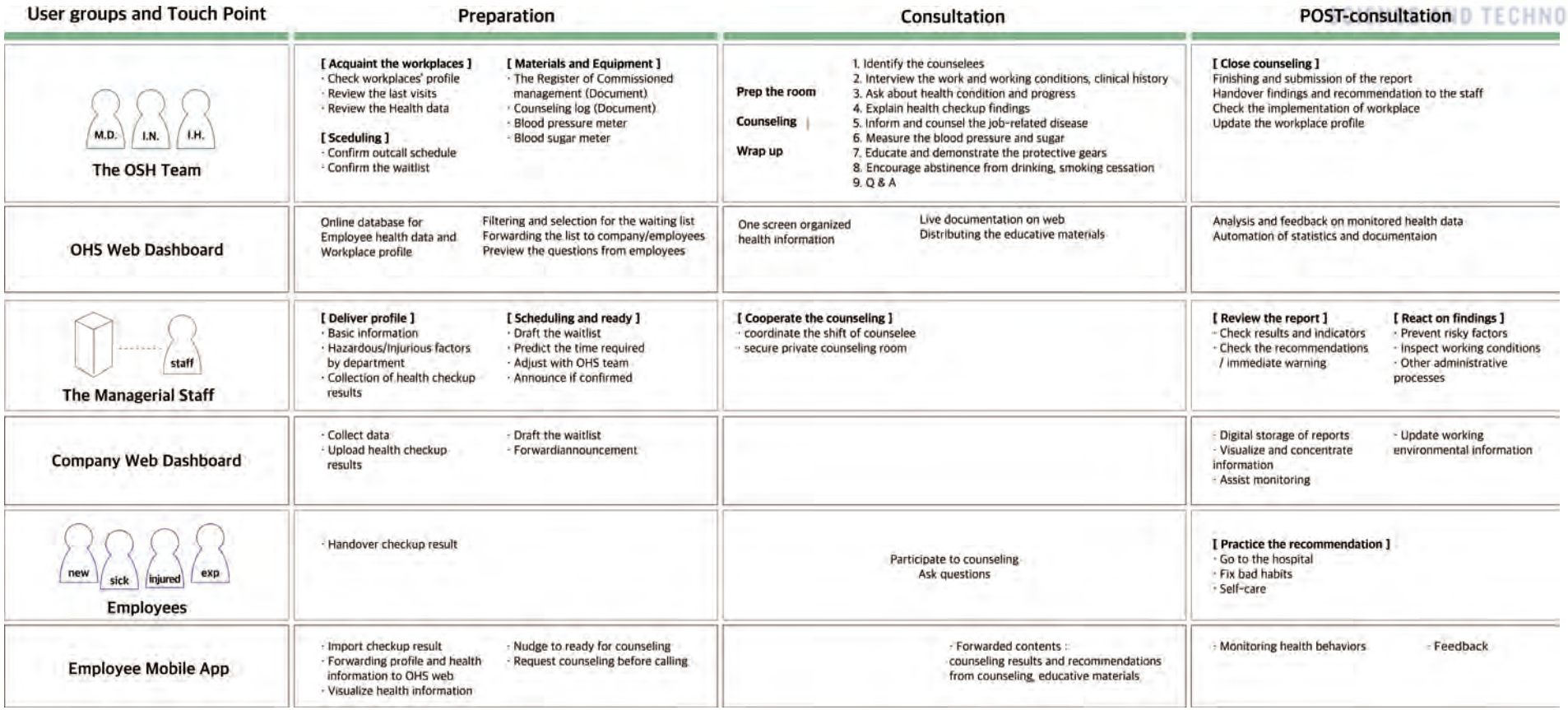


Figure 2. Task Flow

M.D. refers to Medical Doctors. I.N. refers to Industrial Nurses. I.H. refers to industrial hygienists (occupational hygienists). The odd rows of user groups describe their tasks and actions obtained from the observation and interview. The even rows describe the intervention points (touchpoints) of the platform. Functions are listed up, which are prospective to assist the task for each user group as above.

application for individual employees.

Information Architectures (IA) of OHS Web Dashboard and Employee Mobile App had been drawn to convey the basic structure and primary functions of those two agents. Designers have aware that these IAs are rough drafts and expected to fix.

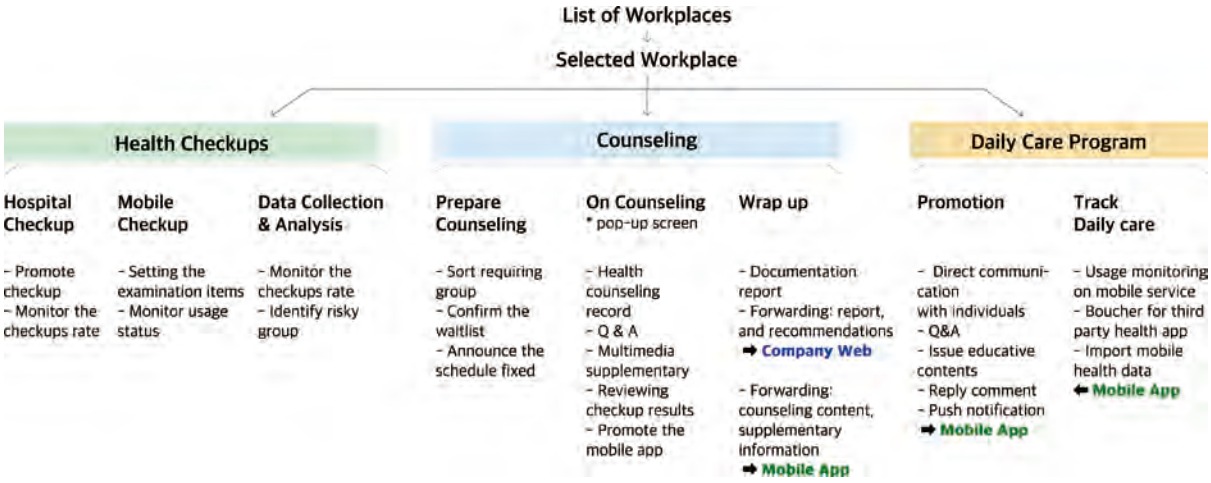


Figure 3. Information Architecture of OHS web drawn from Initiation

User Stories (US) had been prepared two sets of user stories representing the two end-user groups, the OHS practitioners and the employee group to figure the system requirements out. The prepared set were expected to ignite conversation within a team to establish a shared understanding in later review phase. The storied had written with the vocabulary of the OSH team as observed through interview to stay in the natural language of the user; such terms as workplaces (“사업장”), the checkup rate (“수검률”), the monitoring subject (“요관찰자”, requires monitoring and with minor symptoms), and the abnormal subject (“유소견자”, have abnormal result at clinical index).

Template	Contents
As	An OHS practitioner (Nurse)
I want	basic statistical graphs such as the ratio of ureter and checkup rates, along with basic information on workplaces
So that I can	quickly skim over to identify who needs management among all workers by looking at

As	An OHS practitioner (Nurse)
I want	Multi selection the risky groups from the list
So that I can	determine the number of people to consult before a particular date to visit

Table 5. Examples of User Story for OHS web (Translated from Korean)

Figure 4. Wireframe of OHS web drawn from Initiation

Wireframes illustrate the requirements found from user stories. Figure 4 is one screen example which is the 'Counseling' page. This screen includes the subject's identity, input slot for measurement, environmental risk factors at his work. What had been critically considered at the drawing of wireframe was the lack of information and understanding on counseling UX and context. Therefore, wireframe and all the diagrams and user stories above were considered a set of *Croquis*. Those croquis works were utilized as communication equipment for the next phase, Review 1. The conversation on the draft sketch had expected to encourage more variety in conversation and questions from participants then high-fidelity digital prototyping.

Corresponding to IAs and User Stories, the initial Wireframes of OHS Web Dashboard and Employee Mobile App have been drawn on Figma [37]

Insight for agility: Limitation of Vacuum Design

Upon the design team's proposals, it was necessary to confirm how much the medical team agreed the design would be helpful. The plan's contents were only shared on documents among the research

associates. Therefore, the design team had merely shallow confidence that their intention delivered on papers could convince them. Moreover, the initiative UX research was so short, so the design team believed that user research was insufficient to elicit enough user experience.

4.2. Review 1: Vision Sharing

The first review had held a workshop inviting whole research associates to build a shared understanding. All five chief decision-makers of four different institutes attended. At the beginning of the workshop, the leading facilitator let the researchers introduce themselves as icebreaking and investigate their background. There were eighteen researchers in a workshop; six from the design team, including the leading facilitator, five from the Medicine department, and seven from the system developing engineers, including a data engineer.

Purpose of workshop

Vision Alignment among the whole research and development team was the goal of the first review. A cross-functional collaboration was demanded in decision-making as the design team spread out plans and widened the project scope. Because user research was short and plain compared to the complex service flow delivered in a long cycle, the insufficiency of UX information to draw a new HIS was filled with extrapolating from the design team. That is why it was necessary to consider whether it was a scheme that everyone could agree.

Procedure of workshop

1. Pre-workshop task: User story necessity Rating (online responses)
2. Vision Sharing: explain IAs and Task Diagram
3. Requirements discussion (1): User Story
4. Requirements discussion (2): User Story with wireframes
5. Benchmark features sharing for Mobile health app
6. Ideation Activity for Mobile health app

With the invitation letter for the workshop, the two sets of user stories were sent as a pre-workshop assignment. The assignment was to fill the rating field on every sentence of User Story and send the result back before workshop day. Each research associate was asked one representative answer, not

individual responses from all workshop participants. The design team expected this rating task to drive the participants to read the user stories carefully and get ready before the discussion. One more advantage that surprised us was that this assignment abled us to check what research institutes evaluated differently before the workshop. Thanks to this, discussions could be facilitated as reflecting where the difference in opinion was the largest.

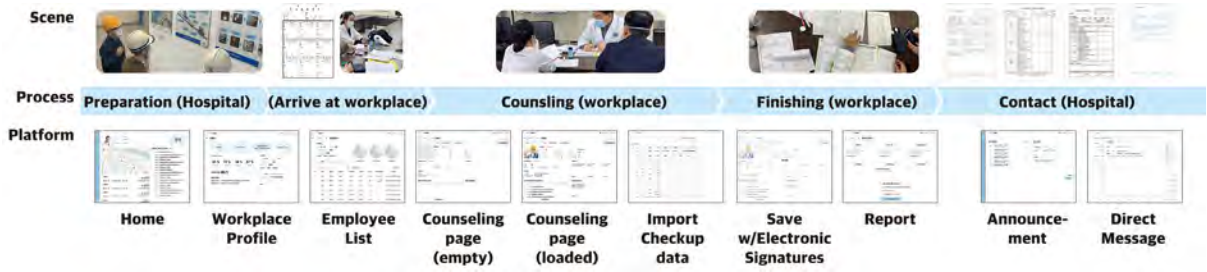


Figure 5. Wireframes mapped along the task flow

Mapping of wireframe is consisted in three layers; Scene, Process, and Platform. The process at the center tells the timeline as axis of tasks in counseling. The photos lined along with the process helps the participant to understand the on-site context of OHS practitioners. Lastly, the platform layer shows the wireframes corresponding to the process and scene. Therefore, it aids to figure out the targeting task and timing which screen stands out to supports.

Those user stories and wireframes had been mapped along with the task flow (Figure 5) in a simplified manner. A large printed map had been posted on the wall so that the participants can follow the main storyline of the management service being discussed at the moment. Also, the **workbook** (Figure 7) had been compiled to deliver the prepared materials into; Information Architectures, two sets of user stories, wireframes. Each participant had been handed out one at the beginning of the workshop and asked to leave note on it freely including the user story rating. By finishing the workshop, the workbook had been gathered for later analysis and scanned.

The leading facilitator explained the Task Diagram and IAs in the vision sharing session to convey what was seen at the initiative user research through the lens of the design team. HIS developing plan was re-written as a dialogue as one service design language over the document containing four different sections.

Requirements discussion in step 3 had gone through line by line upon the task flow of OHS practitioners and mobile users. The leading facilitator had read the user story sentence aloud, and then the workshop participants replied with their evaluation. Questions and comments were openly exchanged. Originally

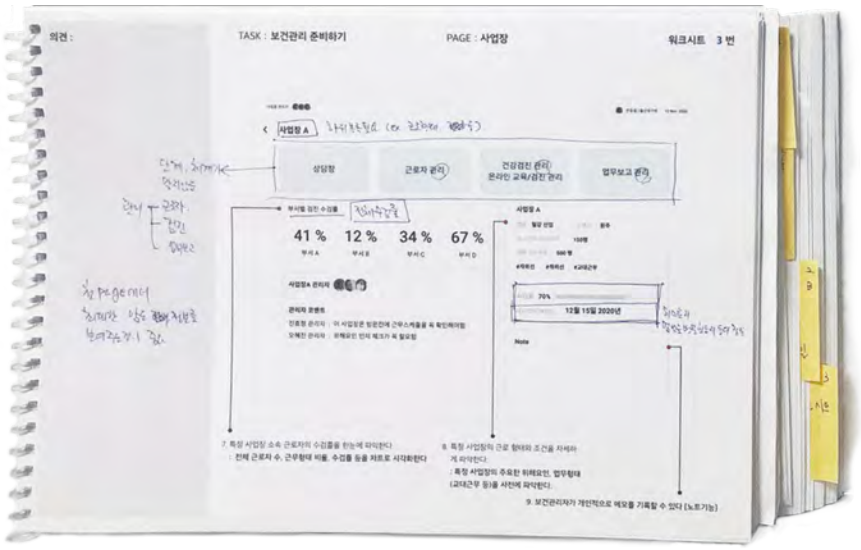


Figure 6. The workbook for the vision sharing workshop

it was planned to divide the participants into four small groups to make the opinion gathering more productive and make the conversation more horizontal by separating the higher managers from their staff. This team-breaking plan had been impromptu shredded since the facilitating design team judging that the discussion could be sufficiently active nonetheless.

To facilitate the participants to distinguish the objectives of the user story and the appearance of its UI, the design team had set the two-step delivery of user stories (step 3) and their corresponding wireframe (step 4). Step 3 delivered written text only so that the discussion can focus on the purpose and value intended for each user story. After had been through all the user stories, the design team showed the corresponding wireframes, which build upon the user stories. Step 4 was a reconsideration of the user stories with its fabricated and visualized wireframed UI draft.

The wireframes had been undergone intense debate, not like the participants welcomed most user stories in step 3. The presentation on the OHS web interface of health information was the central argument. Doctors of Medicine strongly demanded that each screen should be plentiful as possible without processing or simplifying the information. Because the amount of data per screen is regulated for proper level according to the mental model of the design team, it was not ample enough for medical practitioners who are commonly handling tones of data at once.

If the delivery were in one step, showing user stories and its wireframe at once, then the strategies under the user stories might have been rejected following blindly with the wireframe. Therefore, user story

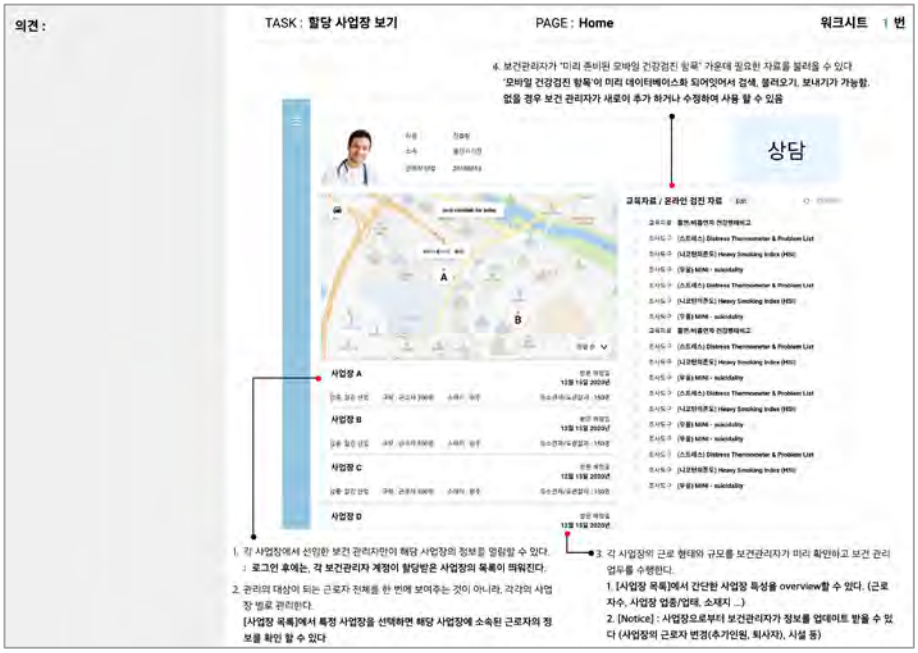


Figure 7. Workbook sheet delivering the User story and Wireframe (Step 4, Review 1)

UI element are linked its corresponding User story with line. The participants discussed on the wireframe following the leading facilitator. 'Task' indicates the main work with this interface. 'Page' indicates the position in web structure.

was a powerful communication tool for this project since more than half of the researchers involved could be influenced more by the visuals than the design intention underneath.

Step 5 was a cooldown and refreshing session telling the benchmarking cases for health managing apps in the market. The design team shared the features in popular health apps and explained those design features. By introducing mobile apps, the participants were expected to be primed in advance of ideation in the next session.

The last step of the workshop was ideation on the employee mobile app. New HIS were demanded to suggest two new service features by apps; the mental health checkups by self-reporting indexes and daily monitoring function for boosting awareness. Not like the mental health checkups would be developed with fore-established medical indexes, the daily log on health conditions had few rationales on what to log. What others do and what is possible to develop does not decide the type of data or response method.

As the result of the discussion from the previous step, six items are decided as requirements; diet, sleep, smoking, drinking, stress, exercise. The design team asked participants to specify the idea on each item; how to collect that information from mobile users. The handout workbooks had empty mobile phone mockups to sketch their ideas. The drawing session had spent ten minutes per item, and the design team

sat close to the participants to help their idea development. The workbooks had collected and reviewed after the workshop.

Retrospective and Limitation

Throughout the workshop, the conversation was led in a casual mood. However, the hierarchy may affect the voice. Frequently the principal participants, such as professors and a CEO, had raised their voices freely. On the other hand, operational level participants rarely uttered answers unless asked to answer specific information like technical or regal issues. Therefore, the discussion went like the fishbowl discussion described in [35] as one suggested formation of team conversation on user story mapping. With plenty of members, a group may require limiting the number of persons engaging in discussion for efficient communication. Fishbowl discussion set loose restrictions. The discussion would start small with the core members and be observed by less-engaging participators. Core member conversation would be transparently delivered to the outer participators, and they can interrupt to say ideas or be asked to join in or out some points.

4.3. Iteration 1

Insight for Design

As a result of the workshop, directions had been set for the next iteration. Information Architectures had revised, and so does the corresponding wireframes for OHS web and employee mobile app. Considering the amount of information per screen was huge, the design team had to find an altered appropriate level of information for health practitioners. Color indication for health status and clinical cutoffs had been started at this point.

Insight for agility

The first workshop was a researcher-oriented discussion. No frontline OHS practitioners had attended. Hence there are blind spots, although the workshop ended up with an agreed conclusion. There was a lack of user-centered derived scenarios of daily monitoring index features. A lack of perspectives from frontline practitioners also means the design team would not have a clear vision of how to consume collected information at the counseling scene. The second review, therefore, expected to visit the OHS practitioners as the essential reviewers.

Outcomes

Figure 8. Wireframe illustrating "Counseling" page of OHS web drawn from Iteration 1

The color code system sign the health checkup result (Left). The vertial alignment of wireframe (right) reflects the counseling dialog process observed; start with the personal information, finishing with the measurement and note.

Index	Color (HEX)		Fasting (mg/dL)*	2 hours Post-prandial (mg/dL)*
Non-diabetic	#48A036		< 100	< 140
Prediabetes	#F5C21E		$100 \leq < 126$	$140 \leq < 200$
Diabetes	#EB5D1A		≥ 126	≥ 200

* Criteria referred from [38]

Table 6. Color indicator for blood sugar level

Index	Color (HEX)	Systolic ($mmHg$)*		Diastolic ($mmHg$)*
Normal	#48A036	< 120	and	< 80
Elevated	#F5C21E	$120 \leq < 129$	or	< 80
Prehypertension	#F5C21E	$130 \leq < 139$	or	$80 \leq < 90$
Hypertension	#EB5D1A	≥ 140	or	≥ 90

* Criteria referred from [39]

Table 7. Color indicator for high blood pressure

The renewal of OHS web had been focused on the delivery of health information and its visualization. According to the demands appealed though discussion in Review 1, the uniformed color indication is applied on the general pages containing the health status. The detailed criteria on each information is grounded on the clinical indexes as possible (Table 6 and Table 7).

4.4. Review 2: Voice from the White Gowns

The design team had visited Wonju Severance Christian Hospital for the second review workshop in February 2021. In response to the invitation sent for the OHS team, six healthcare practitioners attended; two doctors from the occupational and environmental medicine department and two industrial nurses of the OHS management team, and two research fellow doctors from preventive medicine.

Purpose of workshop

The primary purpose was to supplement the perspectives of frontline OHS counselors to the UX/UI design. This second workshop consisted of decision-making processes to avoid groundless choices done by the design team. The candidates competing on interface design were waiting for a pick by the medical team. Workshop material was equipped as printed UI prototypes in A3 size and vital questions.

The core questions were focusing on whether the web UXUI satisfies the demand. The representative five questions were repeated; how clear the interfaces communicate health data, which UX is convenient and appropriate to use, is there any missing function for the OHS management tasks, whether what should be done on this screen is sufficient, and whether the screens following a sound picture of the existing offline consultation.

Procedure of workshop

1. Group dividing: Doctors, and Nurses
2. Vision sharing: Introducing the HIS and project scope
3. Focus Group Interview on the mobile app and daily health log feature
4. Idea generation activity for mobile app
5. UIUX discussion on OHS web

The facilitators were four of the design team. Team dividing was the first activity at the beginning of the workshop. Not only the difference in experience between doctors and nurses in OHS management, but the hierarchy between them was also the reason for splitting participants into two groups. The hierarchy would hinder the conversation as the lesson learned from the first review. Furthermore, doctors and nurses are experiencing OHS tasks differently, as revealed through the initiation interview. They are assigned to different tasks, handling different documents and visiting workplaces at different frequencies.

Consequently, the medical team was divided into doctor group and nurse group. The doctor group consisted of three doctors from the occupational and environmental medicine and preventive medicine department. The nurses' group was two industrial nurses and one doctor from the preventive medicine department.

For the second step, interviewing on the mobile application, the group interview planned a masking trick. The purpose of the interview was to gather the naked opinion of medical experts about the daily health data logging for OHS counseling. Therefore, the design team concealed the six items mentioned from the first workshop but explained only the brief direction of mobile data collection. Through the masking of information, the interviewers could ask the practitioner which information they would choose for the daily health data log.

The facilitators tried to make participants feel free to tell their impressions on the web wireframe to achieve the workshop's goal at the discussion session. More importantly, the OHS team had been encouraged to consider that the design choice would impact their job massively. The facilitators keep cheering them as following mentions;

> *"Choose a draft that you think will be more comfortable with. It is important to designers to know whether the function is difficult to understand or easy end-users."*

It was visible from a remark of an OHS practitioner that rapport was formed between the medical team and the design team.

We will spend the most time on the web dashboard, so please reflect our opinions more (than other user groups).

At the end of the workshop, the OHS team appeared to trust the design team to develop the HIS applications to improve their job and experience.

Retrospective and Limitation

Through the second review phase, outspoken needs of medical practitioners had been identified for data-intensive platform elements to co-work with people within the enterprise. Cooperating workshop earned both the opinion and sympathy on the HIS platform from the voice of the end-user group. A participant from the nurse group mentioned, 'if this is how the OHS management service will be run, we can do the groundwork' necessary to install the new solution. The doctor group disputed the reliability of the six items of daily monitoring. Although they agreed with the idea to promote awareness, they mentioned they may not even consider looking at the log data for health counseling. However, the mental health checkups utilizing mobile self-report features were trusted since those are based on peer-reviewed studies. Additionally, practical issues dragged on the discussion; whose laptop to use, and which data imported from other sources, and how the information would be processed automatically.

This workshop was the first time confirming the needs of the company's web. However, the perspectives of the managerial staff and the circumstance of workplaces had remained unknown. Moreover, the workshop was not enough to discuss how they implement the mental health information in their consultation with employees. In the current regulation, mental health has been unconcerned in OHS management. Hand over the mental health index result would not mean all of consulting is in position. At some points, the OHS practitioners might need additional training for severe illnesses discovered from the mobile app. Furthermore, security management protocol would be demanded to escort the person under mental crisis to a care program.

4.5. Iteration 2

Insight for Design

Through the second workshop, the role of the HIS has emerged as a cooperative online workspace for OHS overarching the medical practitioners, managerial staff of firms, and individual employees. The design insight of the collaborative functions was already noticed in the task flow and involvement points at the initiation phase, yet based on the inference of the design team. The voice from doctors and nurses did convince the necessity and highlighted its importance to other research institutes.

The company side web is an online dashboard corresponding with the OHS web. According to the second review discussion, the Information Architecture of the company web had to consider the distribution process of health data. There are data restricted to managerial staff, such as a detailed diagnosis or mental health status. However, the company web is the primary inlet of essential data, including its profile, list of employees, labor schedule, and workplace condition. Nevertheless, the company web is the final destination of the health management reports. In parallel with the company web design, the mobile app and the OHS web had been improved based on the workshop.

Insight for agility

The web portal site utility was benchmarked, which had been observed from the initiation interview of the in-house OHS case of UNIST healthcare feature in this phase. Still, there was a lack of perspectives from managerial staff.

Outcomes

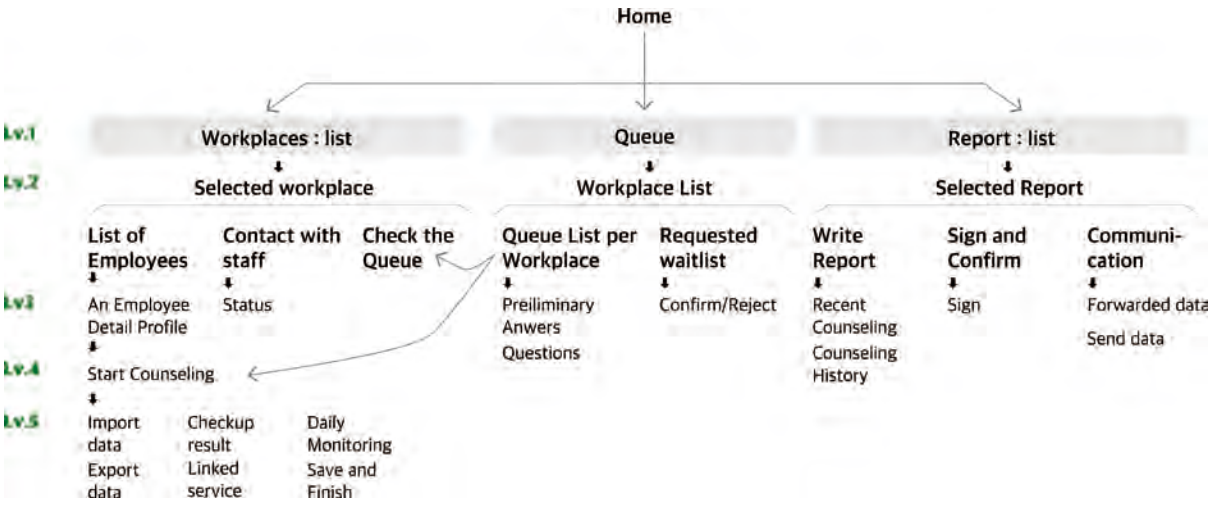


Figure 9. Information Architecture of OHS web drawn from Iteration 1

The IA of iteration 1 is emphasizing the tasks of scheduling and reporting. Hence the "Queue" and "Reporting" functions have been accounted as top important. "Queue" means the waiting list of upcoming counseling, which is set and adjusted by OHS practitioners and the managerial staff. Confirming the queue would determine the time and information consumed in counseling.

Figure 10. Wireframe illustrating the company web drawn from Iteration 2

Wireframes are “Checkup Result (input, left)” and “Reports (output, right).” The company web works as a window of input and the final destination of reports. The managerial staff would preset the profile of their workplace, and the fill out the result table of health checkups. As the outcome of service, they receive the processed information from OHS practitioner with clicking ‘download report’ button.

To implementing the UX quickly from the company side, the company web had been designed mainly. In parallel with that, the mobile app had been improved. Since the six-item log has lacked its rationale, the design team decided to abandon half of them. As a result, the daily monitoring items consist of three items: smoke, drink, and exercise duration. These three are frequently asked indicators at the OHS counseling scene.

4.6. Review 3: Peep the Clients

Purpose of Interview

The third review approached the managerial staff to explore the unseen end-user. As a matter of priorities, the satisfaction of the staff while using the company web was not considered urgently. However, the company web is still essential in the OHS management service and the HIS platform. The managerial staff is the frontline client in an organization who receives the service outcomes of OHS management. The others at the manager level would be reported processed results from that staff. Further, the role is vital as a representative of an organization on HIS platform. If there is no engagement and information update from the managerial staff, the burden is on the nurses inevitably. .

Procedure of Interviews

Wonju Severance Christian Hospital OHS team had invited designers to their regular visiting and arranged interview meetings for the 22nd to 23th, two days in March 2021. Since this study has no priority or exclusion on companies, the selection of interviewees had been entrusted to the OHS team. Therefore, the design team at the visiting day had been following the management schedule fixed already. Unlike the pre-conducted two review phases, the third review had been allowed only a limited time. The net interview time ware less than thirty minutes on average because the informants were the managerial staff who are on-duty hours.

1. Visit the workplace
2. Introduce the HIS development project and design team to managerial staff
3. Interview 1: Ask the management circumstance and process
4. Interview 2: Discussion on wireframes of the company web

Denotation is used on study participants to protect the identities of participants and companies. C1, C2, C3 stand for the companies, and S1, S2, S3 are the staff that belongs to those companies, respectively. S1, S2, and S3 were those who communicate with the OHS practitioners directly. They are the managerial staff in charge of occupational health management in a company.

Company	Description	Staff	Description
C1	A medical supplies manufacture with production-oriented workplace	S1	Concurrent manager at higher position
C2	A pharmaceutical company run cleanroom related extra health checkups	S2	Exclusive occupational health manager distinctive from occupational safety section
C3	Medical equipment manufacturer with production-oriented workplace	S3	Concurrent manager at an entry-level position

Table 8. The companies and the interviewees participated to the third review (Denoted)

Only S2 has hired as the managerial staff exclusively for the OHS task. According to the interview, C2 employed persons in charge of safety management and health management independently. S1 and S2 were concurrent on additional positions in their company. In terms of the company's size, C1, C3 are medium-sized businesses holding under 200 employees. C2 has reported more than 700. However, only some employees work at the Wonju branch facility and are overseen by the Wonju Severance Christian Hospital OHS team.

The design team visited C1 and C2 on the first day and C3 on the day after. A total of four designers were dispatched to the site, two people a day. Because the site situation could not be expected, the design team had to ready to improvise the interview according to the interviewee's situation. The essential question was on how the managerial staff work and communicate with the OHS practitioners. The secondary question was how they think about the newly developing HIS. Therefore, the interview with presenting wireframes had done only at the C2 and C3.

The interviewees varied in the types of OHS managers, as mentioned in the pre-conducted studies. So does their position in their organization and the data-consuming process. This study is not suggesting which type and structure are superior. However, HIS platform may be welcomed more by staff familiar with software utilities, such as Microsoft Excel, as mentioned from S2 and S3.

The design team could investigate how to communicate with the OHS team. They utilize mobile social networking service (SNS) applications (e.g., KakaoTalk), phone calls, and email. KakaoTalk, the chatting room-based SNS, is used to schedule the outcall and deliver the medical data file. From S2, the design team could become aware that there are requests from the company for the extra reports, including statistic result on OHS management. In the case of C2, concerning the hazardous substance in their facility, the executives account the OHS management seriously and hold regular meetings on it. Hence, they require extending processes on the raw data and default OHS management sheet.

The design team could not observe the managerial staff's personal computers and how they handled the related data files. Instead of pushing them to share their desk, the design team encouraged the interviewees to take the casting vote on UI features as much as possible. Although it was explicit information, S2 and S3 delivered feedback and ideas on the wireframe, such as the following;

S2 : How about visualizing how much have counseling done out of the list?

An investigation on resources and efforts for OHS management could have enriched the user experience of the company web, although the OHS platform demands no transformations on the organizations.

4.7. Iteration 3

Insight for Design

Eventually, what the third review was telling is to revise the OHS web. Improvement on the communication pages involved automating the health data process between the OHS web and company web. Especially co-working features such as the entire OHS report foams had to be recreated onto the platform.

Insight for agility

The early development stage of the new HIS for the OHS management service was finishing at this point. The next step would be to apply visual design and polish the wireframes as royal to the UX as possible. Visual design and development of the higher fidelity prototypes will follow.

The design team can suggest an analytic approach for neater service as the pioneer who designed the data collection plan. Although the medical team developed the algorithm for mobile health checkups, only the design team understood the blueprint of comprehensive service. Therefore, the design team can forecast the holistic service scenarios grounded rationale from the type and collecting frequency of data to their value when accumulated.

Outcomes

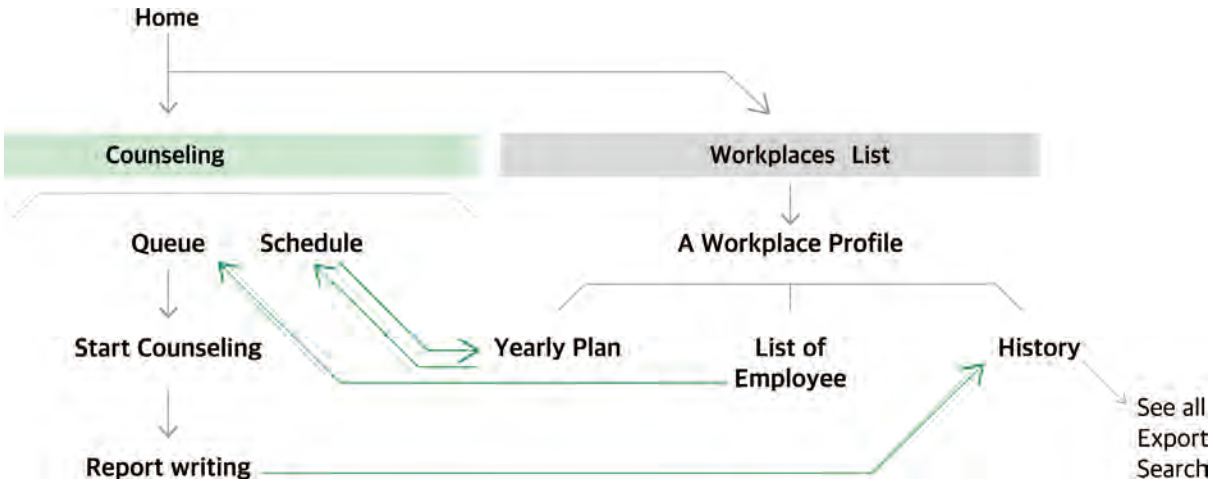


Figure 11. Information Architecture of OHS web drawn from Iteration 3

The IA of OHS web holds only two main structure eventually. The unnecessary functions are eliminated, such as editing the mental health index, and handling the third-party app data. Also, the distribution of information is highlighted with green arrows as the need to clear identification of data processing path.

For the information processing of consulting results, the revised UX distributed data source according to the specialties in an OHS team. The nurses, doctors, and industrial hygienists work on the OHS web simultaneously. The data stored from the OHS web is conveyed to the company web with the basic statistics automatically processed.

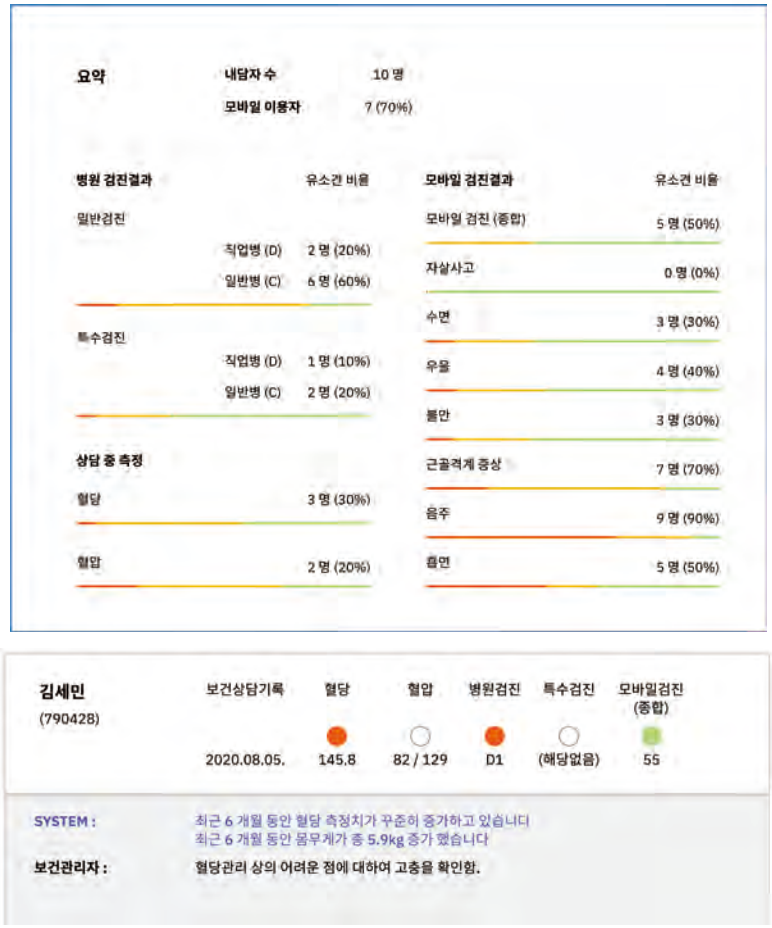


Figure 12. Wireframed UI features of "Reporting" pages of OHS web drawn from Iteration 3

The visualization of automated basic statistics (the top), The list to summarize the counseling and health status of employees (the bottom) according to the color index.

UX and visualization improved for the co-working between the company and the OHS team, including the cutoff indicators for easier understanding of mental health checkups, percent distribution chart as visual aids, system-assisted monitoring features on longitudinal data based on the recreated counseling report.

VI. Discussion and Conclusion

In this case study, the early development of an online health information system have been underwent collaborative and adoptive approaches following agile principles for occupational health and safety management service. This strategy resulted in the decision-making at each design improvement inviting the medical professionals and research associates.

This study suggests the iterative and collaborative design process as the Agile approach utilizes conversation encouraging methods, such as user story. OHS information system has been designed through an adoptive research framework. For productivity, the design team facilitated workshops and opened up the drafts at each phase to the other research organization and frontline OSH team. It was possible to earn remarkable findings and insights that beyond the expectation from the beginning when only a few researchers aware of the problem context dealing with.

The iteration and review study framework had consisted of three rounds, and the reviews expanded the understanding more profound like stepping-stones. More importantly, the reviews have built a user-centered perspective not only for the design team but also for the other researchers in this project. The OHS practitioners from a tertiary hospital engaged in the UXUI design activities as a critical end-user group. Activities of review phases were mapped out to implant the cross-functional collaboration between the designers, developers, doctors, and nurses.

The OHS online platform, the outcome of this study, has three groups of end users; the OHS practitioners, the managerial staff, and the individual employees in the company. The touchpoints were derived from the initial user study and confirmed again in the later review with the OHS practitioners. The OHS web dashboard, the company web dashboard, and the mobile application connect each end users with the health data and consultation results.

As a HIS, the OHS platform suggests the staff-orient applications working as the data-management system and planning and team management equipment. The OHS platform would store the health data from the companies and more than 500 employees supervised by Wonju Severance Christian Hospital, such as profiles, the accumulated dataset of health checkups and mobile logs, the outcomes of the OHS practices. Those data would be processed and distributed with proper visualization for each endpoint.

Scheduling the outcalls is the fundamental task of practitioners for regular maintenance and timely intervention on health consulting. Therefore, scheduling tasks implemented in the web dashboards, such as ‘Queue.’ New service features, mobile mental health checkups and daily health logs, are incorporated on the service scenario. The information system delivers the information to the OHS practitioners with

the assistive features, such as cutoff and color indexes, in sake of lower down the cognitive burden to implement the unfamiliar health data.

Participatory activities in the form of workshops would deliver control and ownership about the study outcomes. The participated stakeholders are the managerial staff, frontline medical practitioners, and the developing research associates. Additionally, those experiences are expected to make them feel free to give opinions and feedback for the succeeding stages of this study.

As far as this study reaches, HIS development for OHS management is found from the mid-90s [40, 41]. Since then, occupational health and safety have been improved and evolve along with the industry. It has only recently become possible to find research on OHS management adopting agile principles [42]. Even so, the management system yet focusing the internal management system of a company.

Therefore, this study would convey the unique health information system encompassing a large-scale management service through entrusted OHS practitioners. Following the prior researches, this study would contribute to improving OSH management and health at work. Moreover, strategies to collaborate acquired through this study would be extendable not only for occupational healthcare but also in other fields where attempts cross-organizational therapeutics.

VII. Further study and Limitation

The study focused on the early design stage and how to make the cross-functional team working together, concentrating on decision-making and managing the collaboration. If further research is undertaken, implementation and user tests on the developed system would follow.

Further, data analytical approaches can fill up the functionality by supporting the OHS practitioners to cover more with a less cognitive burden. The aids of artificial intelligence were illustrated at the idea level by now. However, as aforementioned, the comprehensive service scenario of each end-user and corresponding UIs are waiting to be shared. Therefore, it is an imminent assignment to figure out proper communication tools with data engineers and back-end developers, such as delivering adequate dummy data for representative scenarios and persona.

There is a limitation of an agile approach is only partially applied in the research framework of this study. Although the review and discussion had included the developing crew, this study did not carry the development of working prototype while designing. Fabrication and test the UXUI features would have pulled up the agility of the development better.

Reference

[1] M. Lluch, "Healthcare professionals' organisational barriers to health information technologies—A literature review," *International journal of medical informatics,* vol. 80, no. 12, pp. 849-862, 2011.

[2] D. Isern and A. Moreno, "A systematic literature review of agents applied in healthcare," *Journal of medical systems,* vol. 40, no. 2, pp. 1-14, 2016.

[3] T. R. Campion Jr, L. R. Waitman, N. M. Lorenzi, A. K. May, and C. S. Gadd, "Barriers and facilitators to the use of computer-based intensive insulin therapy," *International journal of medical informatics,* vol. 80, no. 12, pp. 863-871, 2011.

[4] I. Featherstone and J. Keen, "Do integrated record systems lead to integrated services? An observational study of a multi-professional system in a diabetes service," *International journal of medical informatics,* vol. 81, no. 1, pp. 45-52, 2012.

[5] S. Martikainen, J. Viitanen, M. Korpela, and T. Lääveri, "Physicians' experiences of participation in healthcare IT development in Finland: willing but not able," *International journal of medical informatics,* vol. 81, no. 2, pp. 98-113, 2012.

[6] A. Alshamrani, A. Bahattab, and I. Fulton, "A Comparison Between Three SDLC Models Waterfall Model, Spiral Model, and Incremental/Iterative Model," 2015.

[7] 허경화 and 신인재, "산업안전보건교육의 발전과 전망," *한국직업건강간호학회지,* vol. 29, no. 4, pp. 228-234, 2020.

[8] 정명희, 정혜선, and 이복임, "보건관리자의 역할수행이 유병근로자의 출근으로 인한업무손실에 미치는 영향," *한국직업건강간호학회지 제,* vol. 22, no. 2, 2013.

[9] V. Venkatasubramanian, "DROWNING IN DATA: Informatics and modeling challenges in a data-rich networked world," *CHEMICAl ENGINEERING,* 2009.

[10] T. Lippeveld, R. Sauerborn, C. Bodart, and W. H. Organization, *Design and implementation of health information systems*. World Health Organization, 2000.

[11] R. Haux, "Health information systems–past, present, future," *International journal of medical informatics,* vol. 75, no. 3-4, pp. 268-281, 2006.

[12] S. Martikainen, J. Kaipio, and T. Lääveri, "End-user participation in health information systems (HIS) development: Physicians' and nurses' experiences," *International journal of medical informatics,* vol. 137, p. 104117, 2020.

[13] M. M. Yusof, R. J. Paul, and L. Stergioulas, "Health information systems evaluation: a focus on clinical decision supports system," *Studies in health technology and informatics,* vol. 116, pp. 855-860, 2005.

[14] R. Heeks, "Health information systems: Failure, success and improvisation," *International journal of medical informatics,* vol. 75, no. 2, pp. 125-137, 2006.

[15] S. Nerur, R. Mahapatra, and G. Mangalaraj, "Challenges of migrating to agile methodologies," *Communications of the ACM,* vol. 48, no. 5, pp. 72-78, 2005.

[16] L. Cao, K. Mohan, P. Xu, and B. Ramesh, "A framework for adapting agile development methodologies," *European Journal of Information Systems,* vol. 18, no. 4, pp. 332-343, 2009.

[17] R. C. Martin and M. Martin, *Agile principles, patterns, and practices in C#*. Prentice Hall, 2007.

[18] R. J. Holden, M. A. Boustani, and J. Azar, "Agile innovation to transform healthcare: Innovating in complex adaptive systems is an everyday process, not a light bulb event," *BMJ Innovations,* vol. 7, no. 2, 2021.

[19] A. Cockburn and J. Highsmith, "Agile software development, the people factor," *Computer,* vol. 34, no. 11, pp. 131-133, 2001.

[20] D. K. Rigby, J. Sutherland, and H. Takeuchi, "Embracing agile," *Harvard business review,* vol. 94, no. 5, pp. 40-50, 2016.

[21] J. Gothelf, *Lean UX: Applying lean principles to improve user experience*. " O'Reilly Media, Inc.", 2013.

[22] L. Ratcliffe and M. McNeill, *Agile experience design: A digital designer's guide to agile, lean, and continuous*. New Riders, 2011.

[23] O. Safety and H. Administration, "OSHA at a glance," ed, 2014.

[24] M. Baram, "Globalization and workplace hazards in developing nations," *Safety Science,* vol. 47, no. 6, pp. 756-766, 2009.

[25] *Occupational health and safety management systems—Requirements with guidance for use*, 2018.

[26] *산업안전보건법 (OCCUPATIONAL SAFETY AND HEALTH ACT)*.

[27] K. I. H. Association. "보건관리 위탁 (사업안내)." https://kiha21.or.kr/?page_id=52/#d (accessed June, 25, 2021).

[28] D. L. Goetsch, *Occupational safety and health*. Pearson India, 2010.

[29] D.-J. Jo, "A comparison of the occupational accident status by safety and health management type in workplaces," *Journal of Korean Society of Occupational and Environmental Hygiene,* vol. 28, no. 3, pp. 312-318, 2018.

[30] D. R. Roy, "Consulting in occupational health nursing: An overview," *Workplace health & safety,* vol. 61, no. 1, pp. 43-49, 2013.

[31] K. Schwaber and J. Sutherland, "Scrum," 2010. [Online]. Available: http://www.scrum.org/Resources/What-is-Scrum.

[32] J. Sutherland, "Agile development: Lessons learned from the first scrum," *Cutter Agile Project Management Advisory Service: Executive Update,* vol. 5, no. 20, pp. 1-4, 2004.

[33] K. Beck, "Embracing Change with Extreme Programming," *Computer,* vol. 32, no. 10, pp. 70–77, 1999, doi: 10.1109/2.796139.

[34] G. Lucassen, F. Dalpiaz, J. M. E. van der Werf, and S. Brinkkemper, "Improving agile requirements: the quality user story framework and tool," *Requirements engineering,* vol. 21, no. 3, pp. 383-403, 2016.

[35] J. Patton and P. Economy, *User story mapping: discover the whole story, build the right product*. " O'Reilly Media, Inc.", 2014.

[36] Y. Wautelet, S. Heng, M. Kolp, and I. Mirbel, "Unifying and extending user story models," in *International Conference on Advanced Information Systems Engineering*, 2014: Springer, pp. 211-225.

[37] F. Design, "Figma: the collaborative interface design tool," ed, 2017.

[38] KoMGI. *Diabetes Quick Rerence Guide for Primary care* (2020). Korean Medical Guideline Information Center: Korean Academy of Medical Sciences [Online]. Available: https://www.guideline.or.kr/func/download_chronic.php?number=530

[39] KoMGI. *High Blood Pressure Quick Rerence Guide for Primary care* (2020). Korean Medical Guideline Information Center: Korean Academy of Medical Sciences [Online]. Available: https://www.guideline.or.kr/chronic/view.php?number=88

[40] D. A. Morgan, "US Army Occupational Health Management Information System Health Hazard Information Module Version 2.2," *Applied Occupational and Environmental Hygiene,* vol. 10, no. 4, pp. 283-288, 1995.

[41] D. H. Wegman and L. J. Fine, "Occupational health in the 1990s," *Annual review of public health,* vol. 11, no. 1, pp. 89-103, 1990.

[42] K. C. Mızrak, "Agile Occupational Safety Management System Model And Evaluation Of The Proposed Model In An Automotive Company," *International Journal of Management and Administration,* vol. 4, no. 8, pp. 228-244, 2020, doi: https://doi.org/10.29064/ijma.726602.

Acknowledgment

This research was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea. (Grant Number: HS20C0110)

I would like to send gratitude to those who participated in the interviews, workshops, and observations. Without their devoted engagement and persistent cooperation, this thesis would not have been possible.

I owe my supervisor, Professor Dooyoung Jung, numerous constructive comments and warm encouragement during my degree years. As I always said proudly, the only reason I choose UNIST and Human Factor Engineering for my graduate program was him. I would like to thank Professor Hwang Kim for the insightful guidance and inspiration that he showed me. I could make a liftoff for my new voyage into the jungle of design as he did open my eyes wider. Also, Professor Chiehyeon Lim has always welcomed me with thoughtful attention and advice on my studies.

Moreover, the support was invaluable that I had from colleagues who struggled with me side by side. I appreciate the experience with Jiyoung Lee and Hyojeong Jin. It was indeed my pleasure to work with them.

I am also very grateful to Healthcare and Interface Lab that have taken discussions and enrich my work. I received generous support from all members, especially from Sunmi Lee. Additionally, the advice and comments given by Yoon Heo and Kwanglo Lee have been a great help throughout my degree.

The warm words from my great friend Seunghee Lee, whom I had the best tea breaks in my life, were a tremendous support. Her presence was vital in the journey of endeavor.

All would not have been started without my mother, Seonok Im, and her unconditional love. I dedicate my last words of gratitude to her who always embraces me, and encourages me to be myself.

Appendix

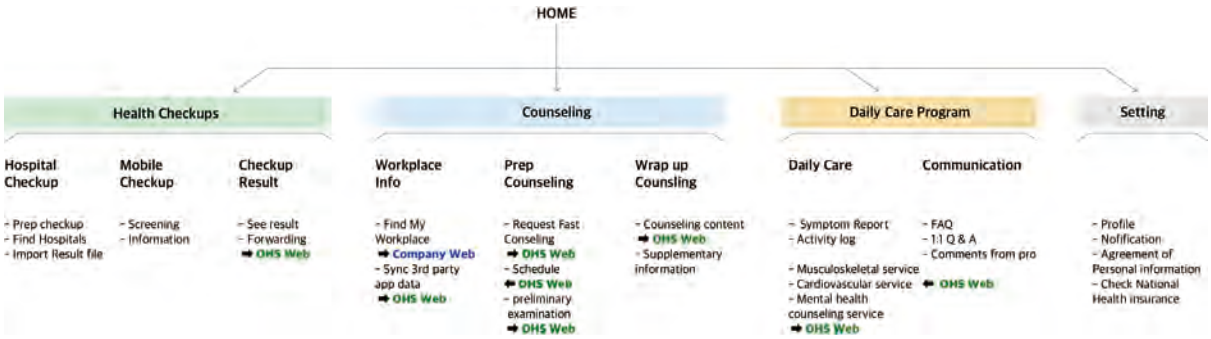


Figure I. The Information Architeture of employee mobile app from Initiation

Figure II. Wireframe of "counseling" page of OHS web from Initiation

Figure III. Wireframe of "List of employee" from Iteration 1

Figure IV. Wireframe of "Report" from Iteration 1

Figure V. Wireframe of "Profile of workplace" from Iteration 2

Figure VI. Wireframe of "Counseling" from Iteration 3

Figure VII. Wireframe of "Counseling" from Iteration 3 (Zoom in)

Figure VIII. Wireframe of "Rerporting" from Iteration 3

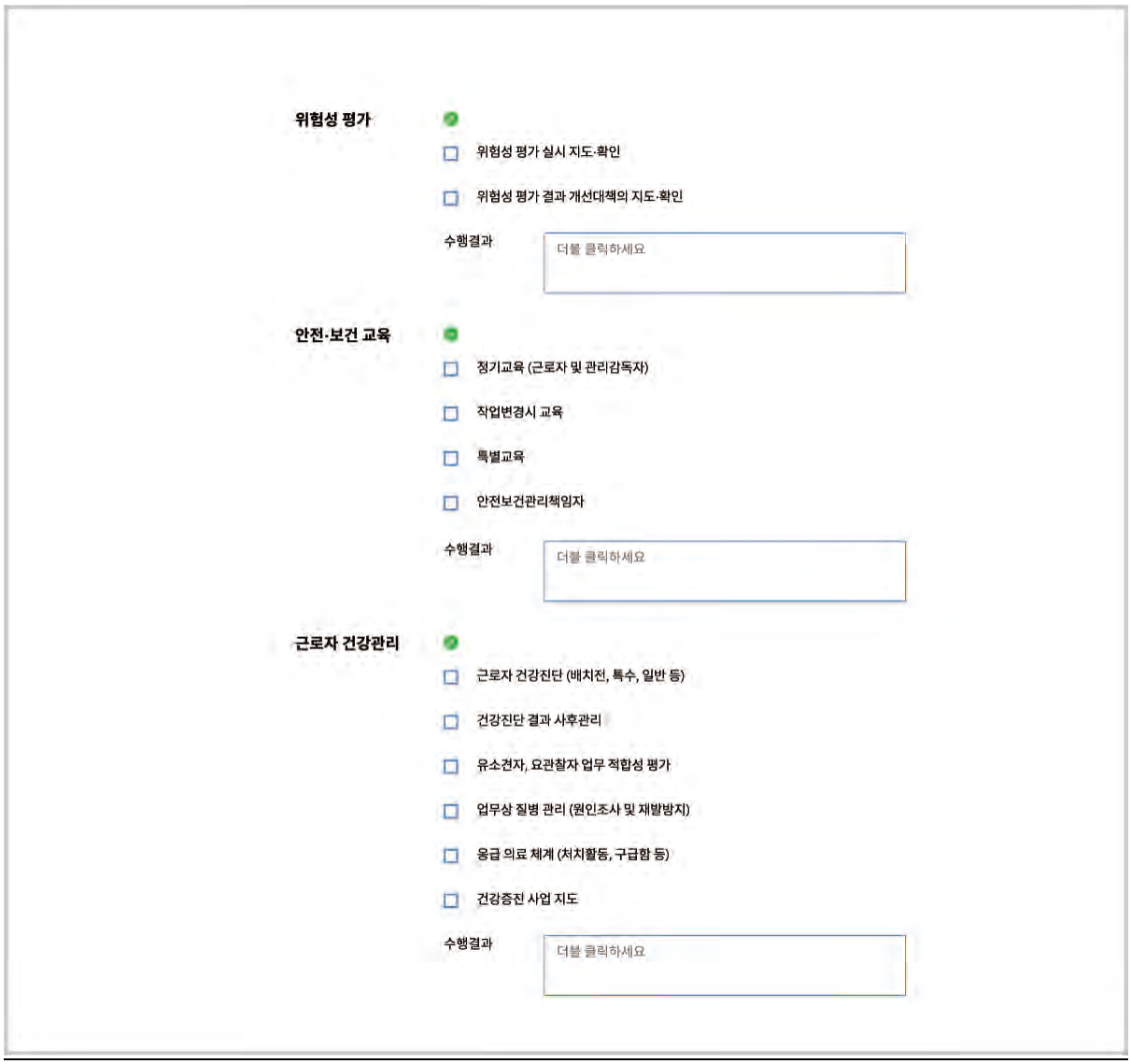


Figure IX. Wireframe of "Counseling" from Iteration 3 (Zoom in)